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ABSTRACT

This paper describes and evaluates the National Technical Institute for the Deaf's (New York) Computer-Aided Transcription System (C-Print), a computer-aided system for transcribing speech to print in the college classroom. The system involves a hearing operator/transcriber typing the words of the teacher and students as they are spoken. A real-time text display is available for the deaf student to follow on a laptop computer or a television monitor. In addition, the text file is stored in the computer and can be edited, printed, and distributed later to students, tutors, and instructors. To accommodate the gap between speech and transcription speeds, the system uses both a computerized abbreviation system and text condensing strategies. Deaf or hard-of-hearing college students (N=19) who received C-Print services in mainstream classes provided feedback through questionnaires and interviews. Students perceived the system as providing very thorough information by capturing nearly all important details of a class and by giving this information permanence in a manageable file or print form. Most students preferred C-Print to using notetakers and interpreters, since both notetakers and interpreters are forced to summarize information rather than providing it verbatim. Five figures presenting the data are appended. (PB)

Evaluation of a Speech-to-Print Transcription System as a Resource for Mainstreamed Deaf Students

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Evaluation of a Speech-to-Print Transcription System as a Resource for Mainstreamed Deaf Students

In the past twenty years, the number of deaf and hard-of-hearing students being educated in classes with hearing students has increased significantly at both secondary and postsecondary levels (Moores, 1992; Rawlings, Karchmer, DeCaro, & Egelston-Dodd, 1986). A major concern for these students is the adequacy of classroom communication, and there is good documentation of the communication difficulties faced by deaf students in mainstream classes (Osguthorpe, Long & Ellsworth, 1980). Researchers and practitioners have noted that students face communication difficulties even when an interpreter and additional support services are provided.

Although the instructional conditions at the secondary level are somewhat different than those at the postsecondary level, the difficulties faced by deaf and hard of hearing students in mainstream settings in understanding the teacher and in participating in class discussions and activities have also been well documented (Kluwin & Stinson, 1993). One example of these difficulties is being able to understand hearing classmates. Many hard-of-hearing and some deaf students use Frequency Modulation (FM) systems to supplement their lipreading of the teacher. Usually the FM microphone is worn by the teacher. When the student's hearing-aids are switched to receive the FM input, they generally cannot hear their classmates' discussion. An interpreter could convey the students' discussion, but students who use FM systems often have poor receptive sign skills.

Providing for adequate communication for the deaf or hard of hearing student in the mainstream classroom is a complex and challenging task. A reasonable approach is to provide the support services best tailored to the individual student's needs, within

constraints such as cost and availability. The traditional support services of interpreting and notetaking serve some students adequately. FM systems are also helpful to many students. However, other forms of support may provide the best access to communication for many students and merit investigation. One such form of support, which NTID has developed, is a computer-aided system for transcribing speech to print. We have called this system the "NTID Computer-Aided Transcription System," or "C-Print."

Description of C-Print

The C-Print system involves a hearing operator (transcriber) typing the words of the teacher and other students as they are being spoken. The system provides a real-time text display that the deaf student can read on a second laptop computer or a TV monitor to understand what is happening in the classroom. In addition, the text file is stored in the computer and can be edited, printed, and distributed to students, tutors, and instructors after class.

Due to the speed of speech normally used by college instructors (app. 150 words per minute), the system cannot provide word-for-word transcription. Therefore, C-Print uses two strategies to achieve the goal of including as much of the relevant information as possible: (a) computerized abbreviation system to reduce keystrokes, and (b) text condensing strategies. The system employs ordinary word processing software which is augmented with a computerized abbreviation system to substantially reduce keystrokes. A set of phonetically-based rules for abbreviating words has been developed, as well as procedures for training operators in using these rules. To deal with rapidly spoken lectures, the project developed text "condensing" or reduction strategies. The goal of these strategies is to reduce the number of words and abbreviations typed while preserving

meaning and keeping the message displayed as near verbatim as possible. Pilot data indicate that C-Print captures approximately 66% of the information spoken in class and 76% of the important information (Everhart, Stinson, McKee, Henderson, & Giles, 1995).

Purpose

Evaluation efforts completed to date will be described. Two types of evaluation data will be reported: (a) student reactions as indicated by questionnaire responses and (b) detailed descriptions of how students use the system and their satisfaction with the system, as indicated by responses during in-depth interviews.

Method

Participants

The participants for this study were 19 deaf or hard of hearing college students (10 females, 9 males) who received the C-Print support service in one of their mainstream courses in the RIT College of Business or Liberal Arts between the spring quarter of 1994 and the winter quarter of 1995. The students provided feedback about the C-Print system through a questionnaire and/or an in-depth interview. This sample was approximately half of the students serviced by C-Print during the above time period.

Courses

For this study, students were drawn from eight RIT courses served by C-Print, three business and five liberal arts courses. These courses were taught by three different faculty members in the College of Business and four in the College of Liberal Arts. Eight students were served in a business course; 11 were served in a liberal arts course. One was served in two liberal arts courses, but completed only one questionnaire and one interview.

Twelve students were served in courses that were more lecture-oriented, four in more discussion-oriented courses, and two in a course that had approximately an equal amount of both lecture and discussion. All students had trained notetakers and tutors available in their courses, and all but two students had interpreting services as well as C-Print. These two students agreed to use C-Print instead of an interpreter.

Questionnaires

Questionnaire data was collected in order to examine the ease of understanding classroom information using the C-Print system and the perceived usefulness of C-Print relative to more conventional support services offered to mainstreamed deaf students (i.e., interpreting, notetaking). Eighteen students completed a questionnaire concerning the usefulness, benefits, and preferences related to use of the C-Print system. The number of respondents differed for some of the questionnaire items for various reasons (e.g., two items were added to the questionnaire at a later date, some students did not experience both types of display to be able to respond to an item).

Three areas involving student perceptions that were of central interest included use and understanding of the real-time display, use and assistance provided by the C-Print hard-copy text/notes, and the overall evaluation of the system.

Use and understanding of the C-Print real-time display. Eleven students were asked to respond to two items (specifying "interpreter" and "C-Print display: TV or laptop," respectively), written as follows: "How much of the lecture can you understand from watching the (interpreter) (C-Print display)?" The circled percentage for each item (e.g., 0%, 10%, 20%, etc.) provided a subjective estimate of a student's level of understanding.

All eighteen students were asked: "Often the C-Print Operator has to summarize information. Is that acceptable to you? Do you feel you are getting the important

points?" Thirteen students also responded to the question: "Sometimes there are errors in the C-Print display. How do you feel about them? a.) The errors don't really bother me. b.) The errors that bother me are:_____." In addition, 10 students indicated their preference for the type of C-Print display they watched during class by circling either "On TV monitor" or "On laptop computer monitor."

Use of and assistance provided by the C-Print hard-copy text/notes. To indicate how much the C-Print notes helped them with their course, all eighteen students circled one of four possible ratings: "Do not help at all," Help me a little," "Help me enough," and "Help me very much." Seventeen students also circled which they used more: "Notes from Notetaker" or "C-Print Notes."

In addition, all eighteen students indicated how they used the C-Print notes to study by circling one or more of the following choices: "a.) Skim the notes and highlight important information," "b.) Make an outline from the information," "c.) Note unfamiliar vocabulary & ideas," and "d.) Other." To indicate their preference for how the C-Print notes were distributed, 18 students circled either: "Paper copy of notes" or "Notes distributed electronically (through VAX)."

General Evaluation of the System. Students indicated the assistance of the C-Print system as a whole by rating how helpful the system would be "if no interpreter and no notetaker are available." All eighteen students chose one rating from the following four: "C-Print not help at all," "C-Print help a little," "C-Print help enough," and "C-Print help very much."

Interview

The purpose of the in-depth interview was to extend understanding of how students perceived the effectiveness of the C-Prints system and how they used it to aid learning in

the mainstream classroom. Sixteen of the deaf and hard of hearing students who received C-Print services in class also participated in an in-depth interview. All but one of these students also completed the questionnaire. For this study, only six of the students' interviews have been analyzed.

Some of the information obtained from the interviews touched on the same issues addressed by the questionnaire. However, the elaborations that students provided, such as exactly how they benefitted from the hard-copy text/notes, is a unique contribution of the qualitative study. The interviews were open-ended and participants were encouraged to pursue their own line of reasoning.

Procedure. The interviews were conducted in a quiet room with either one or two students. Interviews were 30 minutes to an hour in length. The interviewer began by explaining to the student(s) that the goal was to obtain information that might improve the C-Print system which is being piloted in the classroom. The students were also assured that all their comments would be kept confidential.

The interviews included issues similar to those addressed by the questionnaire items, but permitted more extensive answers that revealed the students' personal perspectives in a richer, more detailed way. A voice interpreter repeated the interviewer's and respondent's sign and voice communication into a tape recorder, and verbatim typed transcripts were generated from the audiotapes. The typed transcripts were first coded into a number of categories and then collapsed into three larger categories corresponding to this study's three main topics of interest: (a) use and understanding of the C-Print real-time display; (b) use and assistance provided by the C-Print hard-copy text/notes, and (c) overall appraisal of the system. All the data of the interviews were assigned to one of these three categories by

one coder who also prepared a summary of the information within each category. Within each category, comments were divided into subtopics.

Results

The results are both quantitative (i.e., the questionnaire data) and qualitative (i.e., the in-depth interview responses) in nature. The quantitative and qualitative information has been organized around this study's three main topics of interest: (a) use and understanding of the C-Print real-time display, (b) use and assistance provided by the C-Print hard-copy text/notes, and (c) overall evaluation of the system. Both quantitative and qualitative data are discussed under each main topic, however only qualitative data is available for a few of the subtopics.

C-Print Real-Time Display

Use of the real-time display. In using the C-Print real-time display, students revealed through their interviews that they would not constantly watch the display, but would go "back and forth," dividing their attention between the display and the teachers, as the following comment indicates:

> To be honest, when the lecture is going on, I go back and forth between the teacher and the TV. But if I understand with the laptop, it is clear. It doesn't mean the interpreter doesn't do a good job but sometimes it is a lot, overwhelming all that information, trying to memorize everything. But if I can look at it on the laptop on C-Print, then I can understand it. Looking back and forth I miss what is happening sometimes actually what is going on with the interpreter. But the information is wonderful on the laptop.

Understanding of the real-time display. According to responses during the in-depth interviews, students felt that they were getting complete information with C-Print and that this facilitated comprehension of the classroom discourse. For some students, the amount of information provided by C-Print made a significant impression regarding the classroom

dialogue. The following comment shows how one student developed a new appreciation of the complexity and richness of the classroom dialogue with C-Print.

Interviewer: Do you have some opinions or faults or comments about C-Print that you would like to add?

Informant: Well, I would say that it helps a lot. And it surprised me, because I never realized how much information was provided in class. Before, I always thought that the teacher did not provide enough information and it was boring; but when I was using the C-Print, it seemed more interesting. It makes me feel like I have been missing something in the past. Like I missed the last few years.

Comparison between understanding of C-Print and understanding interpreter.

From analysis of the questionnaire responses, students understood a higher percentage of the class lectures using C-Print compared to using an interpreter (Wilcoxon match-pairs signed-ranks test, $z = -2.52$, $p < .025$). The median percentage of lecture information understood using an interpreter was 70% (range = 0-100%), whereas the median percentage using C-Print was 90% (range = 50-100%) (see Figure 1).

During their interviews, some students stated that they perceived the information provided by C-Print as more complete than that provided by an interpreter. As one student said,

> I am a fifth year student. I have experienced many interpreters, and I know that I have missed a lot of information. I have seen them do it. And I know that on the C-Print that all the information is there.

One issue may be the modifications that the interpreter makes to facilitate the signing of the information and to support lipreading. Another student commented:

> When I watch the interpreter and the teacher, I know that the interpreter is changing what the teacher is saying a lot, and I don't like that because I feel I am losing a lot. Most of the time I will ignore the interpreter nd pay attention to the teacher. Some interpreters I have had a few times, and I know if they are good or not. So it depends on the interpreter.

Adequacy and comprehension of summarized information. Although the C-Print operator condenses what is being said and does not type every word that is spoken, some students felt that the information was so complete that it had a verbatim-like quality. In the in-depth interview, one student commented:

> (For a course served by C-Print alone,) I would understand everything that is going on in that classroom at 100% because everything would be recorded.

From the questionnaire dat more students (17 out of 18) reported feeling that the summarization done by the C-Print operator was acceptable and that they were getting the important points of the lecture compared to the one student who did not feel the summarization was acceptable (chi-square = 17, $p = .00$).

A student responded to an interview question about the extent that the operator summarized information as follows:

> Yes, I accept that it is summarized, I can hardly tell if it is summarized. It looks like she is just typing every single word that the teacher is saying. I can hardly tell that she is summarizing. When I look at the interpreter, I can tell that they are summarizing. So I can see the difference.

The nature of the real-time display. According to interview responses, students' concerns about the real-time display in class included the lag between the time the words are spoken and the time they appear on the monitor (app. 3 seconds) and excessive correction of typing errors at a cost of losing information presented in class. More students (11 out of 13) responded on their questionnaires that the errors present in the C-Print real-time display did not bother them as compared to students who reported that some errors did bother them (chi-square = 6.23, $p < .025$). The interview revealed that students preferred that the operator, rather than spend time correcting typing errors, leave the errors and continue to transcribe in order to capture as much information as possible.

Most importantly, the student interviews revealed a preference for a display on a second laptop computer as opposed to on a full-sized television monitor. Although this preference was not significant in the questionnaire data (chi-square = 1.6, $p > .20$), a trend was present such that 7 out of 10 students preferred watching the C-Print real-time display on a laptop computer monitor.

One reason for this preference, as revealed in the interviews, was that it was easier to go between watching the teacher and the laptop monitor, as illustrated by the following quotation:

> I would say that I would prefer to use the laptop because I would be able to go back if I wanted to. Also, it is easier to move your head from a laptop to a teacher. When you are using a TV monitor, it is more difficult to see them at the same time.

Another advantage of the laptop is that it provides three or four times more lines of text than does the television monitor; that is, there is substantially more information, as the following interview excerpt indicated:

Interviewer: O.K. I want your opinion of another student's comment. They said, "I prefer the laptop display because there is more information there. More information I can read, back-up and read if I wanted, compared to the TV." What do you think of that?

Informant: I think that he means that on the laptop the words, the sentences are there for a longer period of time than on the TV, because of the spacing. I think it is about the same, but it looks like on the TV, because the words are bigger, they move faster. So it is like maybe 6 or 7 lines on the TV, but on the laptop they have 20 or 30 lines on one screen, so it looks like there is more on the laptop. That is what I think.

Problems or concerns regarding real-time display. Students recognized the limitations of having the C-Print real-time display in class, as opposed to an interpreter. Interpreters add a more personal touch. With an interpreter, the students watch an individual conveying the message, rather than reading text. Also, for a student without

intelligible speech, participation in class may be more difficult when only the C-Print service is provided. As one student commented:

> The only problem I would see is if I don't have an interpreter–what if the student has a question? How would they ask? Or maybe the student could type the question and it appears on the screen...and the teacher can see the screen, and then they know what the question is.

C-Print Hard-Copy Text/Notes

Degree of benefit. On the questionnaires, students rated the C-Prints notes on how helpful they found them. Due to the small number of subjects, the four rating categories were collapsed into two for analysis purposes: "help little or none" and "help enough or very much." A higher number of students (17 out of 18) rated the C-Print notes as helping enough or very much as compared to students who rated the notes as helping little or none (chi-square = 14.2, $p = .00$) (see Figure 2).

Students' perceptions of hard-copy text/notes. The student interviews revealed a favorable response to the hard-copy text provided by C-Print because of (a) the completeness of the information, (b) the ability to make their own decisions regarding what information is important to study, (c) the opportunity to get a sense of an entire class session and the "flow" of information and discussion, and (d) their ease in use for review and study. In regard to the completeness of the information, one student said:

Informant: Best thing, I get everything from the transcript.

Interviewer: You get everything from the transcript?

Informant: Right. And I would never miss a thing and it would eliminate all the possibilities that I might miss 1% of that, 1% of that, because I think...I usually pick up on maybe a good 65-85% of what the interpreter says.

In regard to being able to decide for oneself what information is important, one student said:

> (In a class with traditional support services), my learning depends on the notetaker, if the notetaker is writing down the information they think is important. There might be other information for that class that might be important. Or there might be some information that the notetaker thinks is important, but I don't think it is important. With C-Print I get everything. So I can make the decision myself.

Some students also noted that they were able to get an overall sense of the sequence of ideas in a class, as indicated by the following exchange:

Interviewer: The C-Print paper notes. What are the advantages, the benefits of the C-Print notes on paper?

Informant: For me it helps me to remember the flow of the class discussion. When I review it for studying, I pick out the key points. I find that better than the regular notetaker, because the regular notetaker is really summarizing everything. This, it gives the flow of the class so that helps a lot.

There was not a significant difference, as revealed by the questionnaire data, in which notes the students used more: notes from notetaker compared to C-Print notes (chi-square = 2.9, $p = .09$). However there was a trend in the data with 12 out of 17 students responding that they used the C-Print notes more than the notes from the notetaker (see Figure 3).

From the interviews, some students felt that the C-Print hard-copy text/notes were helpful because they were easy to study:

> For me, it is easier for me to study from. Also it is easier to get the answers for the homework assignment, because they are right there. And the teacher's comments are right there. So it is easier for me that way.

Some students had mixed opinions regarding the C-Print text/notes relative to those provided by notetakers. Compared to the C-Print text, notes provided by the notetaker would have only the important points, and this conciseness provided for more efficient study and review. One student made the following points regarding this issue:

> (Disadvantage) The detailed information is there. And that is a big advantage. I prefer the notetaker; that is also a summary. The time is very

> valuable, and it can sometimes be 10 or 11 pages that we have to read from the C-Print, and sometimes that is just too much. So the notetaker's notes are more summarized, a little bit more brief. And that is something that I prefer over the C-Print notes.

How students used the notes. From the 18 students responding to the questionnaire inquiry about how they used the C-Print notes, 14 students reported skimming the notes, 10 reported noting unfamiliar vocabulary and ideas, only 4 reported using the notes to create their own outline, while 6 reported "other" uses of the notes (see Figure 4).

Similarly, in the interviews, students reported using the C-Print text/notes for study in a variety of ways: (a) skimming the text, (b) reading and rereading the text, (c) noting special vocabulary, and (d) making an additional set of personal notes. One student reported using the following strategies in studying the notes:

> I just read them to see if I know the information. And I know that, know that, fine, no problem. And then I get to something I have not seen before, then I mark it, I mark it up. And then I continue reading, and then I go over it again to figure out what they are talking about, and try to understand everything that is going on. And then like words I never saw before or heard before, I underline. And then I write an explanation about what it means. And I use that for tests. Yes, it helps a lot. It has really pulled my grades up a lot.

Distribution of C-Print notes. Fifteen out of 18 students responding to the questionnaire preferred to have the C-Print notes distributed as a paper copy, 2 preferred distribution through electronic mail (VAX), and one student declined to indicate a preference, stating a desire for distribution by both methods.

Overall Evaluation of the C-Print System

On the questionnaires, students rated how helpful the C-Print system would be in a hypothetical classroom situation where there is no interpreter or notetaker present. Due to the small number of subjects, the four rating categories were collapsed into two: "help little or none" and "help enough or very much." A higher number of students (16) rated

the C-Print system as helping enough or very much as compared to the number of students (2) who rated the system as helping little or none (chi-square = 10.9, $p = .001$) (see Figure 5).

The student interviews revealed that the key benefit of C-Print is that it provides complete information regarding what was discussed in class, as the following quotation reveals:

> You said one situation is you have a notetaker and you have an interpreter. The other situation is that you have C-Print only, right. I would prefer the C-Print only. Yes, I would get all the information, and with an interpreter I may miss some information, and the notetaker may miss some information or may do only summaries. With C-Print I am getting everything, and I can see it on the TV screen or on the laptop, and I can summarize it myself if I want to.

This completeness of information appears to compensate for some of the limitations of the system, such as the lack of personal contact and the support for participating in class provided by an interpreter.

Discussion

The evidence of this study indicates that many deaf and hard of hearing students responded favorably to the form of information delivery provided by the C-Print speech-to-print transcription system. Students perceived the system as providing very complete information by capturing all or almost all the important points and details, and as giving this information permanence. For the real-time display on the laptop that is presented during class, each row of words remains on the screen for approximately a minute, providing students far more time to consider these words than if they were using an interpreter or lipreading a speaker. After class, students can further review the material in exactly the same wording and in much greater detail than notes from a notetaker.

The results of this study are similar to those of a study conducted during the 1980's at NTID with a steno system (Stinson, Stuckless, Henderson, & Miller, 1988). In the previous study and the present one, deaf students assigned higher ratings of understanding to the transcription system (C-Print or steno) than to interpreting. In addition, more students responded favorably to the hard-copy text than to notes from a notetaker in the present study. These results are consistent with those of the previous study in which students rated the printout of the text from the steno system more favorably than the notes from a notetaker. Why might students find the printout more helpful? Comments during interviews for the present study, as well as from the previous study, suggest that the detail of the printout permits clarification of what was not understood during the lecture. Furthermore, while the content of notes varies among notetakers, the printout represents a transcription that approaches verbatim. The results from this study suggest that the C-Print system can get equally favorable evaluations as a steno system, however, C-Print is more cost effective due to its shorter training time (app. 1 month) and lower equipment costs.

There is a need to do more analyses of the current data, to try to evaluate the C-print system with other kinds of classes, and to increase the sample size and representation. There is a need to examine relations between communication background and preferences and response to C-Print. Previous research with steno systems found that students who came from mainstream high school programs and who were relatively proficient in reading, writing, and speechreading tended to prefer the transcription system. On the other hand, students who came from residential/day schools, who were relatively proficient in manual reception but less proficient in auditory discrimination, speechreading, and speech production, were likely to prefer an interpreter (Stinson et al., 1988). It would not be

surprising if a similar pattern of relations existed between communication preference and response to the C-Print system.

In addition, the system has been examined with limited kinds of classes, primarily lecture-oriented courses in business or liberal arts. For certain class settings, such as laboratories, the system may be inappropriate (Haydu & Patterson, 1990). The study's conclusions need to be further qualified by the small sample in which approximately half of the students serviced by C-Print completed questionnaires or interviews. It is possible that students who participated in the study had more favorable attitudes about the system.

C-Print is not a panacea for overcoming communication barriers faced by deaf and hard of hearing students. No single channel of receptive communication (e.g., speechreading, sign reception, reading) can be entirely suitable for all deaf and hard of hearing students under all conditions. Evidence is accumulating, however, which indicates that a transcription system such as C-Print is an effective way of increasing accessibility to information in the classroom.

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Figure 1

Median Percentage of Lecture Information Understood: With Interpreter vs. C-Print

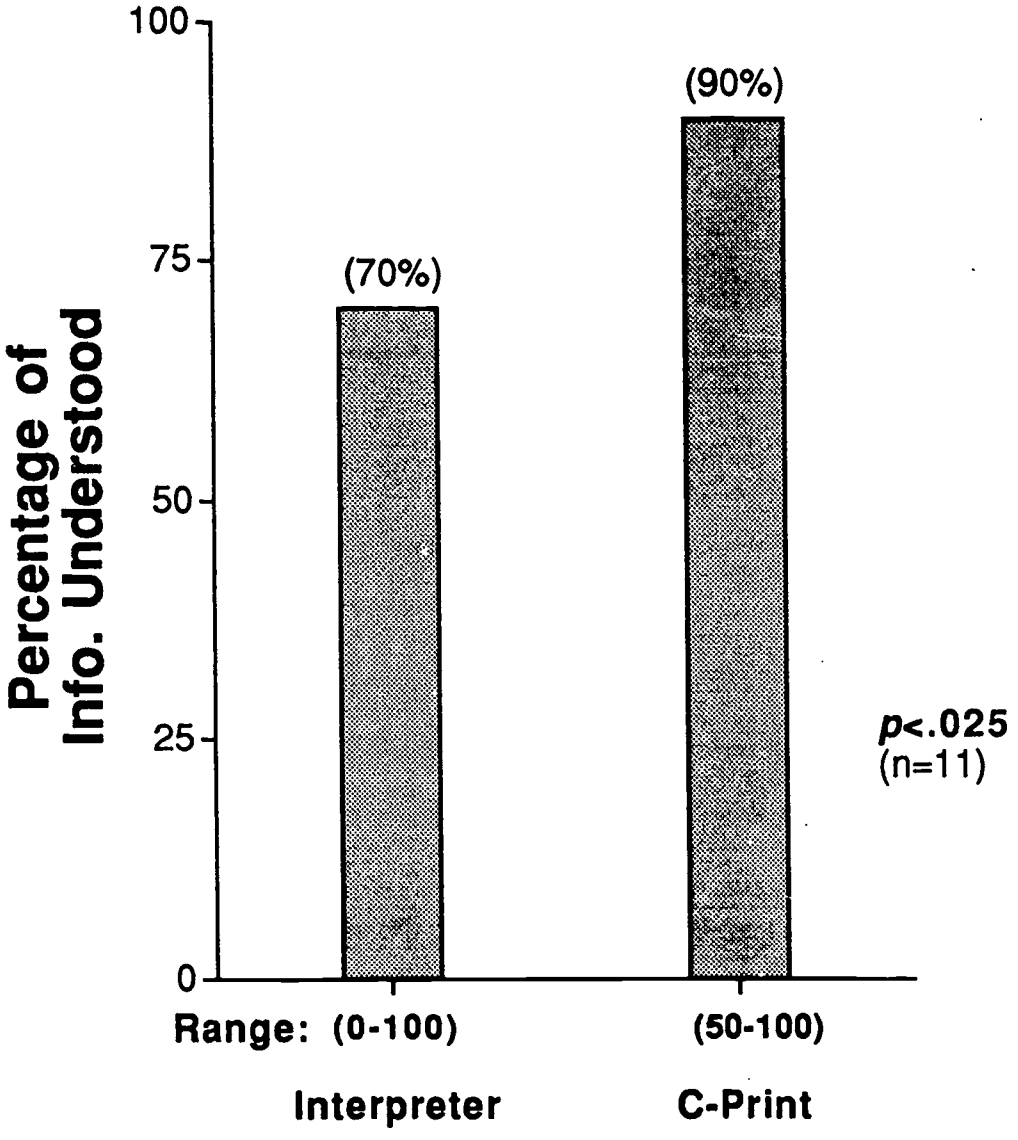

Figure 2

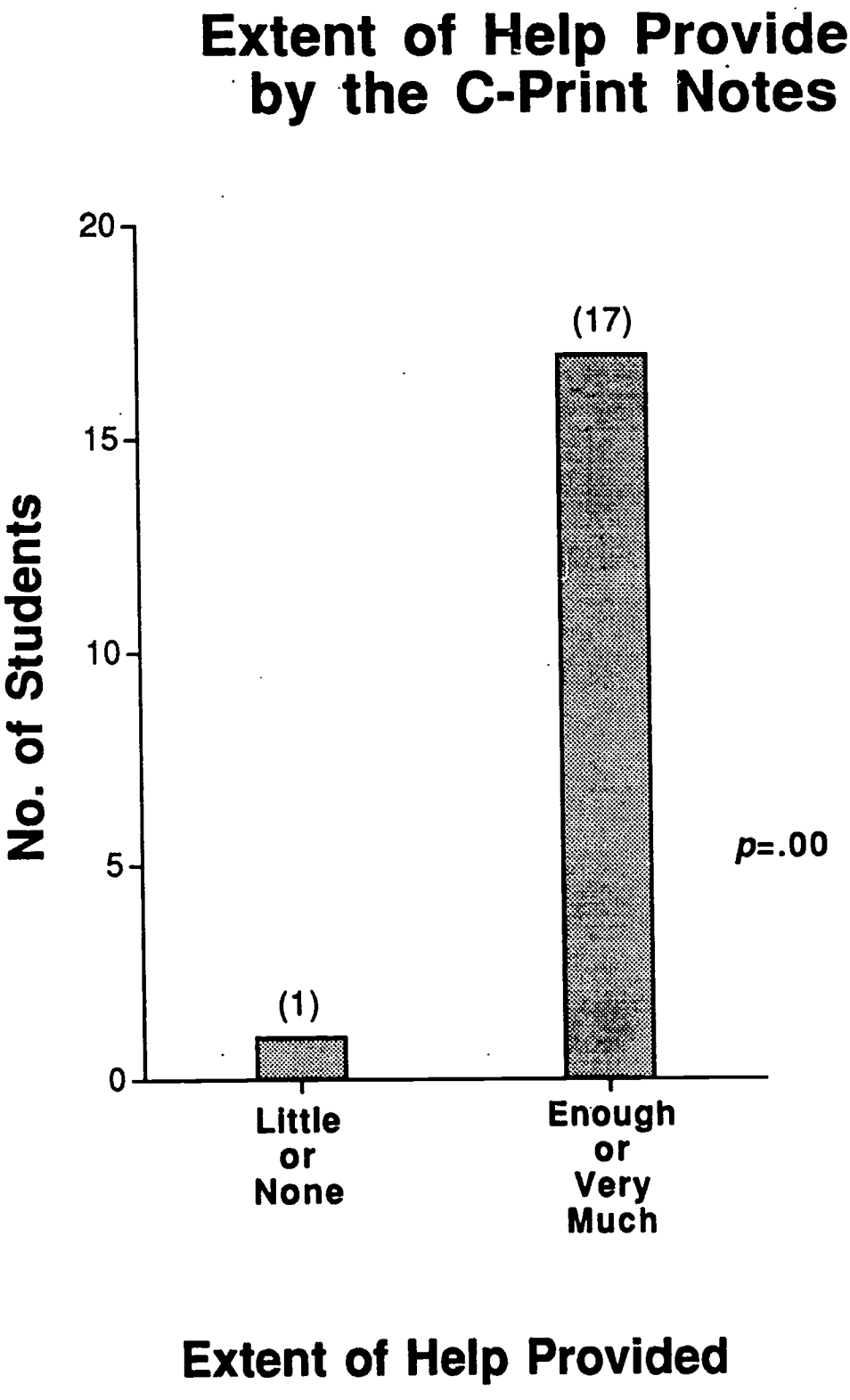
Extent of Help Provided by the C-Print Notes
20
15
10
5
0
No. of Students
(17)
(1)
p=.00
Little or None
Enough or Very Much
Extent of Help Provided

Figure 3

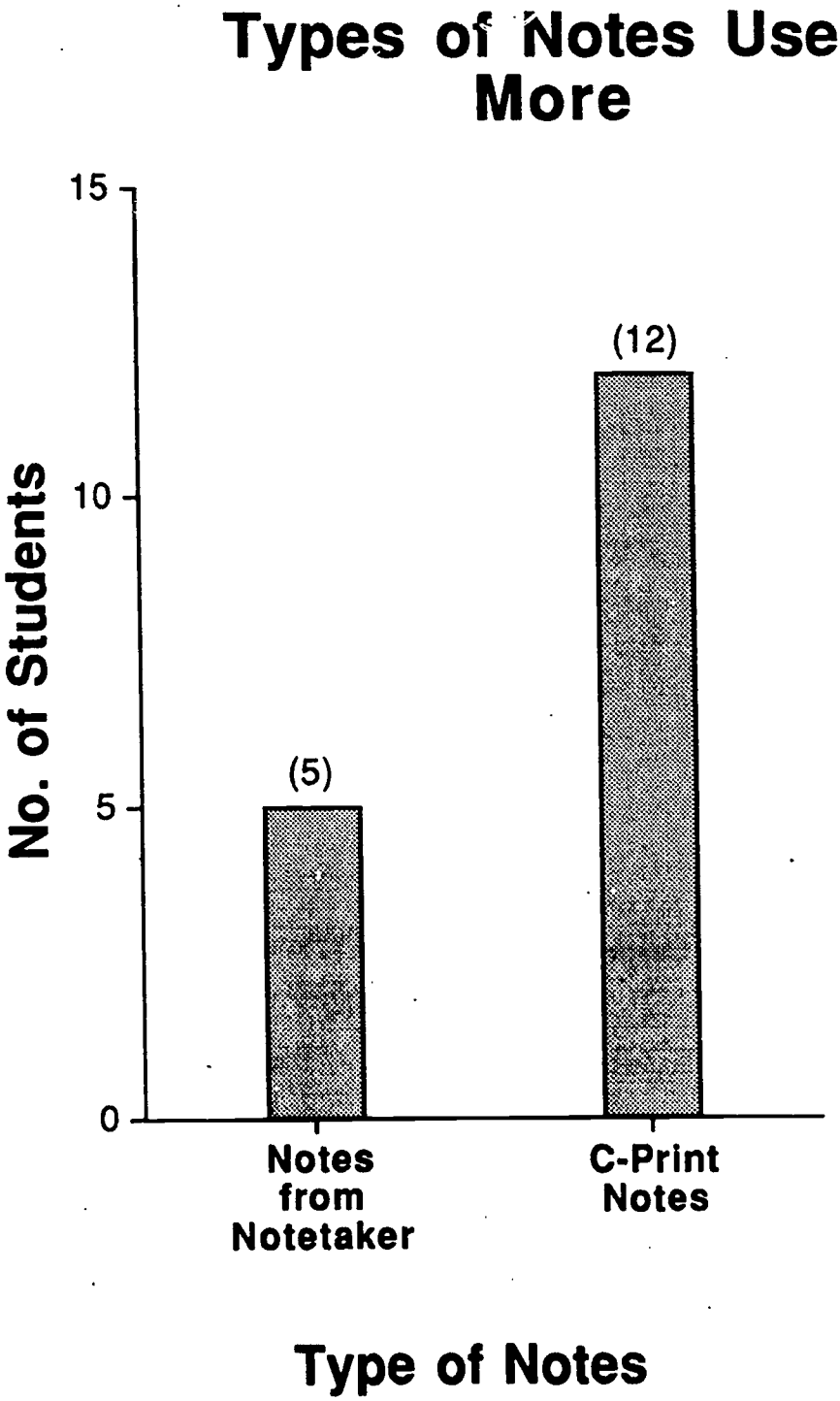
Types of Notes Used More
15
10
5
0
No. of Students
(5)
(12)
Notes from Notetaker
C-Print Notes
Type of Notes

Figure 4

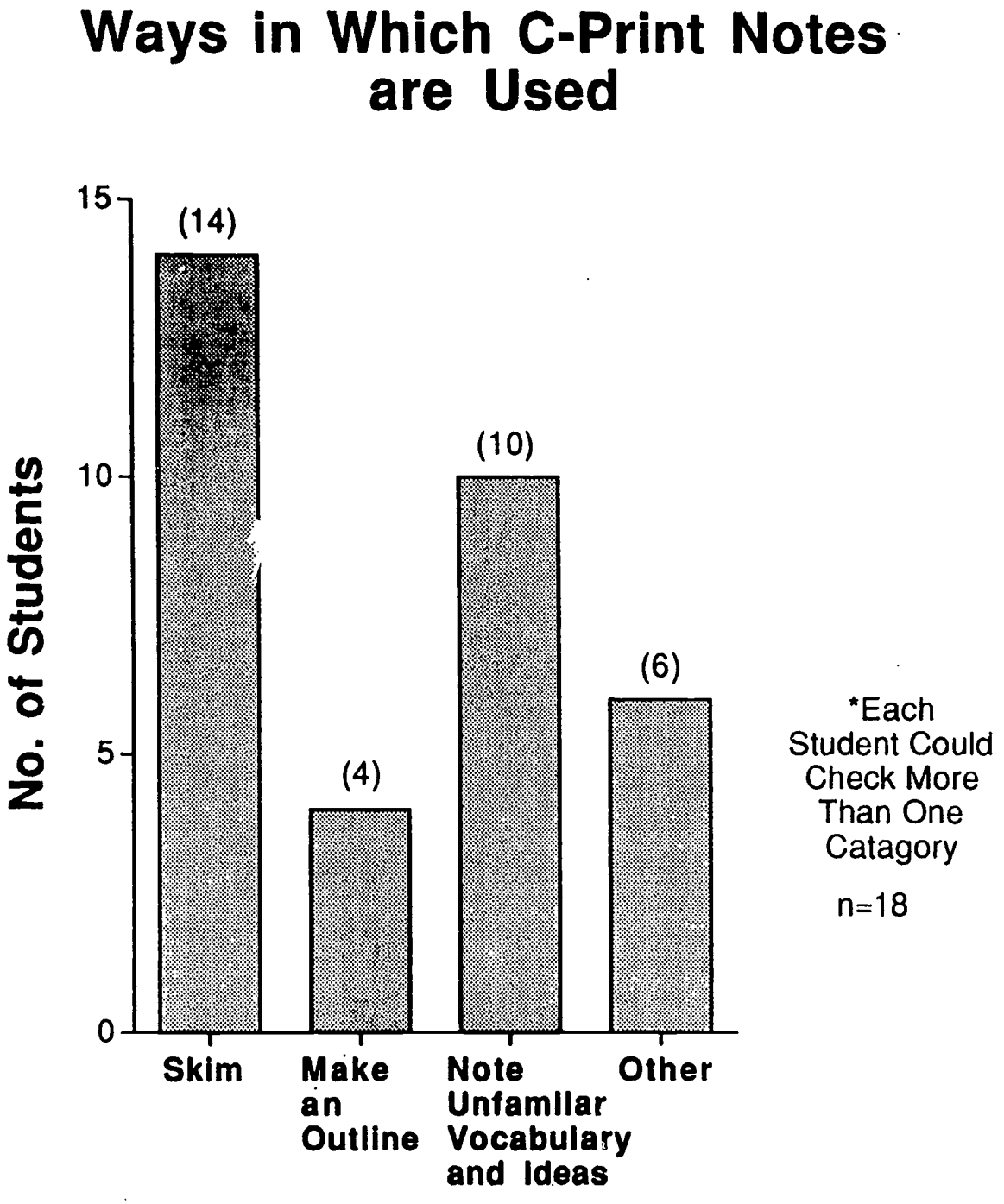
Ways in Which C-Print Notes are Used
No. of Students
15
10
5
0
(14)
(4)
(10)
(6)
Skim
Make an Outline
Note Unfamiliar Vocabulary and Ideas
Other
Type of Use
*Each Student Could Check More Than One Catagory
n=18

Figure 5

Extent of Help Provided by the C-Print System in a Class without an Interpreter or Regular Notetaker